A STRIATED BELT, ITS MANUFACTURING METHOD AND THE ASSOCIATED DRIVE SYSTEM

Background of the Invention

The present invention relates to a striated belt and, more particularly, to a V-profiled belt intended for automotive applications.

The Applicant markets striated belts with V-shaped teeth, the so-called adapted-modulus belts, said belts comprising polyamide 6.6 twisted strands and being intended for electric household appliances, such as linen washers and dryers.

Such belts have a stress-elongation diagram, which characterizes their modulus of elasticity and the average slope of which, between 1 % and 10 % of elongation, is substantially equal to 5.5 daN/% of elongation, per belt width centimeter and per strand.

Said belts are mounted, with a fixed distance between axes, by tensioning them and, once positioned, by releasing them (the so-called automatic mounting process or "snap-on").

Anyway, belts of this type but usable for automotive applications are not on the market at the present time.

As a matter of fact, the use of twisted strands in a striated belt intended for automotive applications, so as to transmit power between an engine and a receiving device, such as an alternator, means a number of problems, especially owing to the acyclic property of the engine output curve, said acyclic feature being sharper for four-cylinder engines than for six- or eight-cylinder engines and being quite greater in diesel engines than in gasoline engines.

Since the electrical power requirements of automotive vehicles tend to increase at present (air conditioning, etc.), the amperage of alternators has to be increased too, and therefore their inertia, which

increases proportionately the stresses imposed upon the belts.

Summary of the Invention

Accordingly, it is an object of the present invention to provide a belt for a motor vehicle, which
5 exhibits a long service life even under high loads.

It is another object of the present invention to provide a belt capable of operating with engines having a marked acyclic feature.

It is still another object of the present invention
10 to provide a belt for a motor vehicle, allowing the filtering out of the high-order harmonic components of the speed and voltage signal output by the receiving device, more particularly when the latter is an alternator.

15 It is another object of the present invention to provide a belt capable of being incorporated in a drive system between a driving shaft and a driven shaft, by means of an automatic mounting operation ("snap-on"), advantageously without requiring a fixed tightener.

20 To achieve at least some of the above objects, there is provided a power transmission striated belt which includes an elastomeric matrix and a lengthwise supporting structure consisting of polyamide 4.6 twisted strands, characterized in that the supporting structure
25 is selected so that the stress-elongation diagram of the belt exhibits an average slope ranging from 12 to 20 daN/% of elongation per width centimeter and per strand, and in that the twisted strands are wound with a very small nominal tension, or almost without any tension, and
30 in that the curing operation and the cooling operation after curing are carried out without any belt tensioning. More particularly, said average slope may range from 12 to 15 daN/% of elongation per width centimeter and per strand.

It should be noted that the Patent Application US-4 701 377 and the European Patent Application EP-381 281 relate to a striated belt, in which the high elastic modulus twisted strands are made of polyamide 4.6, but said documents do not suggest using such twisted strands for a low-modulus belt.

As a matter of fact, it should be observed that the average slope of the useful domain of the elongation curve is in the order of 30 daN/% of elongation per width centimeter and per strand for the motor vehicle belts known at present. Besides, the ultimate elongation of such belts is generally below 10 %.

According to the present invention, said average slope, between 1 % and 10 % of elongation, is preferably substantially equal to 17 daN/% of elongation per width centimeter and per strand.

The belt is advantageously characterized in that its length, as measured on a test bench according to the ISO Standard 9981, is lower by 1 % - 6 % and, for instance, by 1 % - 5 % or by 1 % - 4 %, than the nominal length of said drive system.

In a preferred embodiment, the length of said belt, as measured on a test bench, is lower by 2 %-3 % than the nominal length of said drive system, the preferred value being substantially equal to 2 %.

Advantageously, the belt has a stable operating tension ranging from 14 to 20 daN/width centimeter/strand and, more preferably, ranging from 14 to 17 daN/width centimeter/strand.

The twisted strands of the belt have a diameter d preferably ranging from 0.7 to 1.3 mm.

The space between twisted strands ranges advantageously from 0 (close-turn lay) to 4 d, and preferably from 0 to 2d.

The invention also relates to a manufacturing method for the above-mentioned belt, characterized by the following steps :

a) forming, for instance on a drum, a belt blank, such step including the helical winding of twisted strands at a nominal tension either very low or almost null ;

b) curing the blank without subjecting it to any mechanical tensioning ;

c) allowing the cured blank to cool down without subjecting it to any mechanical tensioning ;

d) cutting the cured blank into individual belts.

The invention also relates to a method of the so-called "automatic "type for mounting the belt onto a pulley of a drive system. It is characterized by the following steps :

i) positioning a mounting tool close to the pulley, so that at least a radial thrust area of the mounting tool rests against the pulley girth, the mounting tool including a ramp area extending from the groove of the pulley to a downward area, for the guidance of the belt right from the groove while keeping it away from the pulley till it reaches a plane spaced from said pulley face ;

ii) radially moving said mounting tool by a lever effect, while following the pulley girth so as to fit the belt into the groove of the pulley while pulling on it ;

iii) once the belt is positioned in the groove, disengaging the mounting tool.

Last, the present invention relates to a drive system between a pulley integral with a driving shaft of a car engine and at least one pulley integral with a driven shaft of a receiving device, such system comprising a belt as defined above and without any fixed tighteners.

Brief Description of the Drawings

Other features and attendant advantages of the present invention will more easily be understood by reading the following description of the preferred embodiment thereof, only by way of a non-limitative example, taken in conjunction with the accompanying drawings, wherein :

Figure 1 is a cross-sectional view of a striated belt according to the present invention,

Figure 2 shows a drive system provided with a belt according to the present invention,

Figure 3a is a stress-elongation diagram corresponding, respectively, to a belt according to the present invention (Curve I) and to a belt (Curve II) not suitable for the present invention, as obtained on a test bench schematically shown in Figure 3b,

Figures 4a and 4b show the comparative drive testing of a car alternator using a belt according to the prior art and to the present invention, respectively,

Figures 5a and 5b show a preferred embodiment of a mounting tool, capable of performing the automatic fitting of a belt according to the present invention, and

Figure 6 illustrates the method for mounting the belt.

Detailed Description of the Invention

An endless belt 10 comprises a lengthwise supporting structure 20 of twisted strands embedded in an elastomeric matrix 21, such as a mixture of polychloroprene rubber or natural rubber or any type commonly known in the manufacture of power drive endless belts, for its good adhesion properties. Such belt is advantageously of the "striated" type, i. e. its inner surface 22 is shaped like teeth 23, the pitch P of which is standardized, as well as their triangular cross-section as shown (V belt) or their trapezoidal cross-section, each reference character H, J, K, L and M in the ISO Standard 9981 also defining the belt thickness, as

measured between the tooth bottom 24 and the outer surface of the belt. The belt 10 cooperates with pulleys 11, 12, 13, 14, 15, 16, etc..., the rims of which have a profile conjugate with that of teeth 23, that is they

5   have grooves arranged in the same way and with a cross-section which is similar to that, e. g. triangular or trapezoidal, of the teeth 23, which they receive when the drive system is operating. The belt 10 comprises two strands 17 and 18.

10   The V-shaped belts intended for automotive drive systems generally have six teeth with a width l = 3.56 mm, i. e. a total belt width L of 21.36 mm.

According to the present invention, the twisted strands are made up of adipamide polytetramethylene or

15   polyamide 4.6. These are resins prepared by polycondensing 1.4-diaminobutane and adipic acid, for instance those marketed under the name of STANYL by the DSM Company. Such resins in the shape of yarns are then prepared into twisted strands.

20   Therefore, belts usable under severe operating conditions, such as those prevailing in drive systems for automotive applications, can be obtained by selecting the twisted strand size and pitch p for the belt to exhibit a stress-elongation diagram having, for instance between

25   1 % and 10 % of elongation, an average slope in the range from 12 daN/% of elongation per width centimeter and per strand to 20 daN/% of elongation per width centimeter and per strand, and preferably substantially equal to 17 daN/% of elongation per width centimeter and per strand.

30   Said slope may, more preferably, range from 12 and 15 daN/% of elongation per width centimeter and per strand.

Besides, the method for manufacturing belts according to the invention differs from that implemented

35   in conventional belts for automotive applications,

wherein the twisted strands are kept tensioned during the whole manufacturing process.

In the conventional method, the twisted strands are first stretched and then helically wound onto the drum carrying the gum sheets.

The tensioned twisted strands in the winding condition are still under tension when the blank is cured. For such curing, the blank is generally arranged in a mold shaped like the belts to be produced, and then it is pressed by radial expansion onto the inner wall of the mold. Such radial expansion increases the tension of the twisted strands.

Said tension disappears at the end of the curing process, when the blank is extracted from the mold and such tension cancellation results in shrinkage and thus in a smaller length of the belt.

In order to avoid such shrinkage, in said conventional method, the twisted strands are tightened upon cooling from the curing temperature down to the ambient temperature, which means that they retain their length and that all shrinkage is prevented.

Such method has a number of consequences :

- when the belt has been mounted, the operating temperature fluctuations result in length changes and, more especially when its temperature increases, the belt is brought back to its initial state, and the twisted strands tend to shorten, which results in an increase in the service stresses in the belt.

As the belt temperature is decreasing, the length tends to increase and the belt slacks, which phenomena is even aggravated by the permanent strain resulting from the twisted strand creep.

On the contrary, when a belt is manufactured according to the present invention, the twisted strands are helically wound on a drum carrying gum sheets at a

nominal tension which should ideally be null but which, in practice, is very low or almost null, corresponding to a winding operation under the lowest possible tension, being understood that some very low or almost null (e. g.

5   below 5 N) residual stresses always remain, which fact cannot be avoided if only owing to the stresses resulting from the weight of the twisted strands.

Afterwards, during the pressure curing process, the blank is pressed onto the inner wall of the mold without

10 any radial expansion and therefore the twisted strands present an almost null residual stress.

After extraction and during the cooling process, the blank cools down without being tensioned. Once the cooling is over, the twisted strands present no tension

15 at all.

Thus, an advantage of a belt according to the invention resides in that the operating temperature fluctuations have much less influence on the belt that when said conventional method is implemented. Such

20 smaller changes in the belt length as a function of temperature also result in a lower tension change, which prevents the belts from slipping on the pulleys, and reduces the generated noise.

One major problem in automotive applications is the

25 acyclic feature owing to the nonuniform time distribution of the alternating piston loads. This leads to a severe stressing of the belts and, more particularly, to a residual stress after stabilization (that is after some operating period) which is quite lower than in the case

30 of drive systems without an acyclic feature, such as the drive systems from an electric motor.

Owing to such severe stresses, up to now it has not been possible to provide belts having an elastic modulus suitable for the so-called automatic mounting of the belt

35 in a car drive system.

Most remarkably, the belts according to the present invention, which have an average slope ranging from 12 to 20 daN/% of elongation per width centimeter and per strand, exhibit a stable operating tension after about ten hours of operation, which is in the order of 14 to 20 daN per width centimeter and per strand.

Good results are obtained with twisted strands having a diameter ranging from 0.7 to 1.3 mm, the distance between twisted strands being in the range from 0 to 4 d, and preferably in the range from 0 to 2 d.

Figure 3a shows the case of two driving belts in the automotive field, comprising six 3.56 mm-wide teeth and polyamide 4.6 twisted strands 20, manufactured according to the above-mentioned method (winding under an almost null nominal tension, curing and cooling without tensioning).

The belt according to Curve I (twisted strands, 470 dtex X 6 X 3) has an average slope, between 1 % and 10 % of elongation (curve drawn using the least-squares method), which amounts to 17 daN/% of elongation per width centimeter and per strand.

The belt corresponding to Curve II has an average slope, between 1 % and 10 % of elongation, which amounts to 11 daN/% of elongation per width centimeter and per strand.

The elongation test, used for such diagrams, is carried out, for instance, on a 200 mm-long strand retained between two jaws, the one 30 being stationary and the other 31 being movable, using a dynamometer (refer to Figure 3b).

The sole object of the above-mentioned average slope is to provide a characteristic value for the stress-elongation diagrams, obtained by means of the least-squares method, but such curves should in no way be regarded as straight lines since, as a matter of fact, at

each point they do have a slope, the value of which varies appreciably along the curve.

A car belt according to Curve I and comprising six 3.56 mm-wide teeth has been mounted onto a drive system without any fixed tighteners. The mounting operation has been performed by stretching the belt to fit it onto the pulleys of the drive system. Once released, the belt is in position with a 2 % elongation, which corresponds to an initial elongation force of 80 daN per strand (refer to Curve I), that is substantially 13 daN per tooth and per strand. After a few hours of operation, the stabilized tension has been measured. Its value amounted substantially to 6 daN per tooth and per strand. Such tension remains stable and the belt exhibits a long service life.

A car belt according to Curve II and comprising six 3.56 mm-wide teeth has been mounted onto a drive system without any fixed tighteners. The mounting operation has been performed by stretching the belt to fit it onto the pulleys of the drive system.

After a few hours of operation, the stabilized tension has been measured. Its value was quite below 6 daN per tooth and per strand, and the belt was inclined to slip on the pulleys, which generated noise and the service life of the belt was not very satisfactory.

Another restraint should be taken into account, especially as regards the filtering properties concerning the high-order harmonic components of the speed and voltage signal output by the receiving device. Such phenomena is more particularly marked when high inertiae are present, i.e. when the motor vehicle is provided with an alternator.

Figures 4a and 4b illustrate this filtering phenomena. Each one shows, in terms of time, the rotation speed of the main shaft (Curve M), here that of a diesel

engine at idle speed, and that of the shaft (Curve A) of a receiving device 14. The belt 10 transmits the speed, resulting from the rotation of the pulley 11, to pulleys 12, 14, 15 and 16 of the receiving devices, more

5 particularly the pulley 14, which drives the alternator having a torque of 3.5 10-3 kg.m^2.

Curve A in Figure 4a has been obtained by means of a conventional belt, comprising polyester twisted strands, after a 48-hour operating time, the belt having reached a

10 stabilized operating tension.

It can be seen that Curve A shows a repetitive anomaly 40 having a more or less stable shape and corresponding to a slope interruption during deceleration. Such anomaly originates more particularly

15 in the fact that the belt passes over to the pulley 14 the acyclic operation of the engine (cf. Curve M). This phenomena is all the more marked as the engine has a more acyclic property. By way of information, a four-cylinder gasoline engine has an acyclic property in the order of

20 6-7 %. Such property is in the order of 4-5 % for a six-cylinder gasoline engine, but it ranges generally from 10 to 15 % for a diesel engine. Some diesel engines even have an acyclic property as high as 20-25 %. Said anomalies 40 are due to the conjugate effect of the

25 engine acyclic property and of the receiving device inertia, and they increase with the acyclic value of the engine and with the inertia of the receiving device.

The curve shown in Figure 4b has been obtained using a belt according to the invention, and corresponding to

30 Curve I in Figure 3a, after a 48-hour operating period. The belt has reached a stabilized operating tension of 15 daN per width centimeter and per strand. It can be seen that said anomaly 40 has completely disappeared. The belt according to the invention has the quite remarkable

35 property of being capable of filtering the high-order

harmonic components of the speed signal output by the receiving device.

The suppression of such anomalies 40 means a longer service life of the belt.

5   The automatic mounting of a belt into a car drive system involves high tensile stresses. The mounting operation may be performed more easily by means of the tools to be described with reference to Figures 5a, 5b and 6. The mounting tool 40, shown in detail in Figures

10 5a and 5b, has a central part 41 provided with a square opening 42 for receiving a complementary part 51 of an actuating wrench 50. It should be noted that the lever 50 may be an integral part of the tool 40. The tool 40 has an inclined conical part 43, at the top end of which a

15 guiding flat surface 44 is provided, and a L-shaped member having a leg 49 extending from the central part 42 and whose flat underside 48 is intended to rest on the surface 61 of the pulley 60, and an end flap 46 bent substantially at right angle in relation to the leg 49,

20 and the inner surface 47 of which abuts against the rim 63 of the pulley 60.

The leg 49 is crowned by a guiding area 45 substantially in the shape of an arc of a circle.

The object of the method according to the invention

25 consists in fitting the belt by a lever effect, using the mounting tool 40, which is guided along the girth (62, 63) of the pulley 60, whether the latter remains fixed or is capable of rotating about a driving shaft received in its central opening 65.

30 The conical part 43, bounded by the inclined flat surface 44, and the part 45 make it possible to guide, by a ramp effect, the side portion 27 of belt 10 from the side portion 26 already accommodated in the groove 62 of the pulley 60, up to the side portion 28, which stands

apart from the surface 61. This is performed by bearing on the lever 50.

The procedure is as follows. The tool 40 is positioned so that the surface 48 of the leg 49 rests on the surface 61 of the pulley 60, and that the conical part 43 and the surface 47 of the flap 46 abut against the girth of the pulley 60, that is the rim 63. Of course, it would be possible to obtain such thrust effect by pressing the tool 40 into the groove 62 of the pulley 60.

The belt 10 is prepositioned in the ramp constituted by parts 43, 44 and 45. By operating the lever 50 in the direction of arrow F, the tool 40 is moved along the girth of the pulley 60 in the direction of arrow F', which results in the fitting of the belt 10 into the groove 62.

Should the pulley 60 be fixed, such travel of the tool 40 is performed with a sliding motion. If the pulley 60 is capable of rotating, such travel of the tool 40 attends the rotational motion of the pulley 60. Anyhow, the lever effect combined with the ramp effect provide an easy fitting.

More particularly, such mounting operation takes place in the plane of the pulley 60 or close to it, which results in the fact that this method is suitable for an exchange in the engine compartment, usually of limited accessibility in automotive vehicles.